MISB MOTION IMAGERY STANDARDS BOARD	MISB RP 0101.1
Recommended Practice **Use of MPEG-2 System Streams in Digital Motion Imagery Systems**	**27 January 2011**

1 Scope

This Recommended Practice (RP) details recommended uses of MPEG-2 System streams in digital, motion imagery systems. MPEG-2 Elementary Stream (ES) and Transport Stream (TS) are appropriate for use under different circumstances. To promote interoperability, reliable system operation, and system development efficiency this RP limits the use of different MPEG-2 stream types in motion imagery applications.

2 References

[1] ISO/IEC 13818-1:2007, *Information Technology – Generic coding of moving pictures and associated audio information, Part 1: Systems*

[2] ISO/IEC 13818-2:2000, *Information Technology – Generic coding of moving pictures and associated audio information, Part 2: Video*

[3] ISO/IEC 13818-3:1998, *Information Technology – Generic coding of moving pictures and associated audio information, Part 3: Audio*

[4] SMPTE 336M-2007, *Data Encoding Protocol Using Key-Length-Value*

[5] SMPTE RP 217-2001, *Nonsynchronized Mapping of KLV Packets into MPEG-2 Systems Streams*

3 Introduction

The guiding principle set forth in the Motion Imagery Standards Profile (MISP) is that motion imagery streams and files must be exchangeable among all systems. In order to achieve this, motion imagery must be interoperable at the file interchange level. Use of commercial standards and products affords a high degree of interoperability, where reliability and signal integrity for transmission and exchange are well understood.

This RP provides guidance to developers of digital motion imagery systems to ensure that their systems are interoperable by setting limits on the use of MPEG-2 ES and MPEG-2 TS.

4 MPEG-2 Standards

MPEG-2 is an ISO standard [ISO/IEC 13818] and consists of three parts that are relevant here:

- Systems ISO/IEC 13818-1 [1] (MPEG-2 TS)
- Video ISO/IEC 13818-2 [2] (MPEG-2 ES)

- Audio ISO/IEC 13818-3 [3] (MPEG-2 ES)

The next sections detail when MPEG-2 ES and TS formats should be used and information that developers of motion imagery systems must consider in their system designs.

5 MPEG-2 Elementary Streams (MPEG-2 ES)

An MPEG-2 ES (Elementary Stream) [2, 3] is a compressed essence bit stream, and the most basic MPEG-2 system stream. Their use in digital motion imagery applications as stand-alone files or streams is generally discouraged for the following reasons:

- By definition, an ES is capable of carrying only one essence type (video, audio, or data). The nature of motion imagery collection, exploitation, archive, and distribution functions requires that complex multimedia contents (video, audio, data, and metadata) be carried together in one stream.
- No standards exist for the inclusion of KLV metadata into ES formats. Some systems insert KLV metadata into MPEG-2 ES private user packets, but these are not implemented uniformly and are not interoperable.
- Not all MPEG-2 decoders accept an MPEG-2 ES.
- The interchange of MPEG-2 ES between systems has proven to be problematic, especially with MPEG-2 software decoders. Because of apparent differences in codec implementations users have experienced difficulty decoding an ES created on encoders from different manufacturers. Interoperability criteria require that MPEG-2 streams created on one system shall be decodable by an MPEG-2 decoder from other manufacturers.

Developers may need to make use of MPEG-2 ES in processes that are internal to closed applications. Developers are discouraged from using the ES format for any exchange between different applications within a single system or between identical systems.

6 MPEG-2 Program Streams (MPEG-2 PS)

The MPEG-2 Program Stream (PS) was originally developed to convey MPEG-2 in an error-free environment, such as a DVD, or for file storage. Program Stream is less versatile than TS. For example, it lacks the error recovery and redundancy facilities of the Transport Stream, and it cannot carry multiple programs. Program Stream is often not supported by decoders.

Program Stream is discouraged from use by MISB standards, but it may be required for STANAG compliance. If a decoder is not able to play a PS but can handle the Transport Stream, then the PS must first be "split" into TS components before decoding and playing. This is not a complex or computationally intensive operation, but must be taken into account if a system must deal with both PS and TS formats.

7 MPEG-2 Transport Streams (MPEG-2 TS)

MPEG-2 transport stream (TS) is a standard format for transmission and storage of audio, video, and data used quite heavily in the commercial/broadcast communities.

Transport Stream is specified in MPEG-2 Part 1, Systems [1]. Transport stream specifies a container format for encapsulating packetized elementary streams, with error correction and

stream synchronization features for maintaining transmission integrity when the signal is degraded. Figure 1 illustrates that a transport stream packet consists of header fields, an optional adaptation field, and a payload field. The header contains a sync byte that denotes the beginning of a TS packet and a Packet ID (PID) that uniquely identifies the packet. An adaptation field may be used to convey information such as the Program Clock Reference (PCR). The payload field contains the actual ES bits.

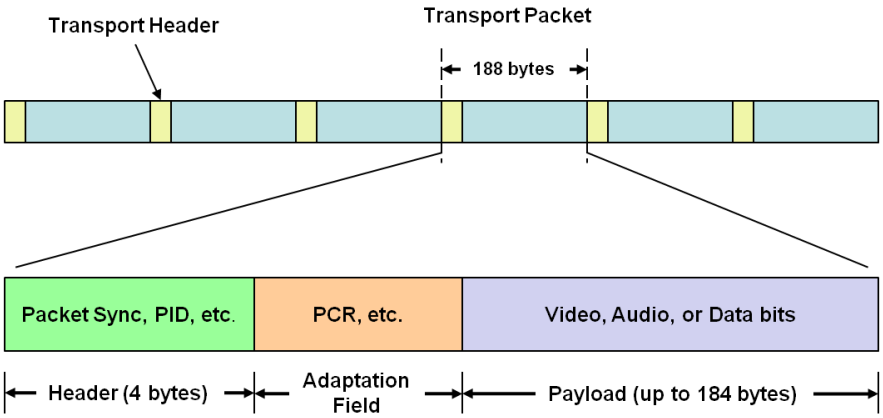

Figure 1: MPEG-2 Transport Packet

MPEG-2 TS should be used instead of Elementary Streams for several reasons:

- The TS format is intended for use in error-prone transmission environments for either file or streaming media applications. Error-prone environments are typical of what may be experienced by fielded military motion imagery systems. Most TS decoders are able to recover when frames are corrupted in transmission.
- Virtually all MPEG-2 codecs can decode the TS format.
- An MPEG-2 TS may contain multiple video, audio, data, and metadata elementary streams together. This is the preferred method for conveying multimedia steams to ensure their continuous, correct timing relationship to one another.
- KLV metadata should be contained within a transport stream as its own elementary stream. The ISO/IEC and SMPTE standards [1-5] define how to carry metadata in a transport stream.
- When KLV is inserted into a transport stream, commercial decoders that cannot decode the KLV can ignore the KLV gracefully. In other words, the presence of KLV does not break the decoding of the video/audio.
- Because MPEG-2 TS is designed for real-time delivery, it is the preferred format when streams need to be decoded and viewed immediately upon receipt. Developers must exercise care when building systems that edit or otherwise alter an MPEG-2 TS. "Slicing" or segmenting a TS stream or file into smaller TS streams must take into account the GOP (Group of Pictures) structure of the MPEG-2 format and consider the impact of B and P frames at file boundaries.

The transport stream utilizes a concept of programs. Each single program is described by a Program Map Table (PMT) that has a unique PID, and each elementary stream associated with

that program is assigned a unique PID that is listed in the PMT. For instance, a transport stream might contain three programs. Suppose each program consists of one video elementary stream, one audio elementary stream, and a metadata elementary stream. A receiver decoding a particular program merely decodes the payloads of each PID associated with its program. It can ignore the contents of all other PIDs.

A transport stream with more than one program is referred to as a Multi Program Transport Stream (MPTS). A single program transport stream is referred to as a SPTS.

7.1 Program Specific Information - *PSI*

MPEG-2 Systems PSI contains six tables useful for identifying where the various essence streams and timing information lies within the transport stream. Only two tables—the Program Association Table (PAT) and the Program Map Table (PMT)—***shall*** be used in TS streams, the remaining tables are optional

7.1.1 Program Association Table - PAT

The PAT lists all programs available in the transport stream. Each of the listed programs is identified by a 16-bit value called *program_number*. Each of the programs listed in the PAT has an associated PID for its Program Map Table (PMT).

7.1.2 Program Map Table - PMT

Program Map Tables (PMTs) contain information about programs. For each program, there is one PMT. The PMTs provide information on each program present in the transport stream, including the *program_number*, and list the elementary streams that comprise the described MPEG-2 program. Each elementary stream is labeled with a *stream_type* value.

7.2 Program Clock Reference - *PCR*

To synchronize content, such as metadata that matches the associated motion imagery, at least once every 100 milliseconds a *Program Clock Reference*, or PCR is transmitted in the adaptation field of an MPEG-2 transport stream packet. The PCR is a 42-bit sample of the 27-MHz System Time Clock (STC) used at the encoder. The value of the PCR is used to regenerate the STC in the decoder.

Timing values in the MPEG-2 TS references this clock. For example, the Presentation Time Stamp (PTS) is a value computed relative to the STC. The first 33 bits of the PTS are based on a 90 kHz clock, while the last 9 are based on a 27 MHz clock. The maximum jitter permitted for the PCR is +/- 500 ns.

7.3 Null packets

Null packets provide a way to form a constant bit rate stream. The PID 0x1FFF is reserved for this purpose. The payload of null packets is undefined, and the receiver is expected to ignore its contents.